

Effectiveness of outdoor mathematics in developing grade 7 students' ability on measurement

Amit T. Tanaji¹, Alnajir H. Usman¹, Potchong M. Jackaria¹, Aljemedin S. Jaudinez¹,
Al-Jayson U. Abubakar²

¹Department of Science and Mathematics Education, College of Education, Mindanao State University-Tawi-Tawi College of Technology and Oceanography, Tawi-Tawi, Philippines

²Integrated Laboratory School, College of Education, Mindanao State University-Tawi-Tawi College of Technology and Oceanography, Tawi-Tawi, Philippines

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ABSTRACT

This study investigated the effectiveness of outdoor mathematics instruction as an alternative to the conventional classroom-based approach, specifically focusing on grade 7 measurement concepts. Students' perception on outdoor activities in mathematics was also measured. A two-group quasi-experimental design was utilized, involving two selected classes from a public high school in Tawi-Tawi, Philippines. One class engaged in outdoor mathematics activities, while the other used the conventional lecture approach. The study utilized a 40-item researcher-made test, a perception checklist, and outdoor mathematics activities, which were presented to a panel of experts for validation and underwent reliability testing. Statistical tools such as mean, standard deviation, and *t*-test were used to analyze the performance of the two groups. Results indicated that students exposed to outdoor mathematics activities showed significant improvement in understanding and applying basic measurement concepts compared to their peers in conventional settings. Similarly, the students reported positive perceptions of outdoor activities. This study highlighted the potential benefits of incorporating outdoor mathematics instruction into school curricula as an innovative teaching strategy to enhance students' learning and engagement.

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Corresponding Author:

Potchong M. Jackaria

Department of Science and Mathematics Education, College of Education

Mindanao State University-Tawi-Tawi College of Technology and Oceanography

Bongao, Tawi-Tawi, Philippines

Email: potchongjackaria@msutawi-tawi.edu.ph

1. INTRODUCTION

Many students perceive mathematics as the most challenging and boring subject in school [1], [2]. Students show low interest in learning mathematics as it is considered difficult [3] and challenging [4], [5]. These misapprehensions about mathematics are common not just among students but teachers and parents as well [6]. Hence, mathematics teachers need to look for innovative strategies that make mathematics lessons engaging to students. The teaching mathematics outdoors can be one of such strategies to stimulate and enhance students' learning experience. By taking learning outside, students will see the real-world and authentic applications of mathematical concepts [7] which may improve students' math understanding [8]. During outdoor mathematics, the students can explore geometry, measurement, statistics, and other math concepts while enjoying the benefits of hands-on learning. This makes outdoor math activities more exciting and fun for students [9], [10]. The growing interest in outdoor education in recent decades supports the shift

towards more student-centered teaching and the constant need for innovative teaching approaches. Outdoor education, defined as taking place outside traditional classrooms in natural environments, is often student-led, collaborative, and heavily influenced by environmental and social contexts where the students reside [11].

Using outdoor activities in teaching has been shown to benefit students beyond academics [12], [13]. Some of its positive outcomes include increased social connectedness and enhanced self-efficacy in leadership competencies [14]. It also positively impact cognitive, linguistic, socio-emotional, and motor skills especially among young children because of its multisensory learning environments [15]. Others have found that outdoor teaching improves social relations, participation, collaboration, and on-task communication among students [16] and improves students' motivation to learn [17]. These findings underscore the value of outdoor learning in fostering essential life skills alongside academic knowledge.

While there are many benefits of using outdoor mathematics, previous studies have shown that many areas still need further research. These include looking for the best way to teach sustainable outdoor teaching [18] and determining the specific benefits of outdoor activities to students' holistic aspects while balancing the academic benefits [19], [20]. There are also challenges to outdoor activities implementation including safety concerns, the need to cover the concentrated curriculum, the lack of necessary resources, and even weather conditions [21]. Others have reported constrained by time, heavy content demands [22], [23], education policy that emphasizes formal assessment [24], and lack of teachers' expertise in conducting outdoor activities [25]. Hence, the gap still exists on how outdoor activities can best be integrated as regular classroom activities [26].

Meanwhile, in any national mathematics curriculum, the topic of measurements holds an important role [27], [28]. In basic education, measurement includes both the measurement of mathematical and concrete objects [29]. Measurement bridges the abstract world of numbers and the tangible realities of our everyday lives. As students progress through their educational journey, the importance of teaching measurements in grade 7 mathematics becomes increasingly evident. Understanding measurement concepts provides a vital foundation as the grade 7 students move from arithmetic to more complex mathematical concepts.

The natural world is full of mathematical patterns and principles that bridge between measurement and the use of outdoor activities. Exploring these in a hands-on manner helps students see the relevance of what they are learning. For instance, students can measure the height of trees, the weight of rocks, or the area of a garden, making abstract concepts more concrete and understandable. These contextual and realistic learning have been shown to aid in the retention [30] and application of mathematical principles [31], [32].

With the many possible benefits of outdoor mathematics and the existing challenges in its implementation, this present study aimed to determine the effectiveness of the outdoor mathematics approach in teaching grade 7, particularly on the topic of measurement. It endeavored to determine how learning mathematics outside impacts students' understanding of mathematical concepts. Further, the study investigated the effectiveness of outdoor mathematics instruction as an alternative approach to traditional classroom-based instruction. Specifically, it aimed to answer the following questions: i) what is the level of performance of the grade 7 students in the pre-test and post-test on measurement in terms of basic concepts and real-life application? ii) do students exposed to the outdoor mathematics approach have significantly higher learning gains than those in the conventional group along the aforementioned variables after the intervention? and iii) what is the grade 7 students' perception on the use of outdoor activities in mathematics? Consequently, it was hypothesized that students exposed to the outdoor mathematics approach have significantly higher learning gains than those in the conventional group after the intervention.

2. METHOD

2.1. Research design

This study utilized a two-group quasi-experimental research design. Two intact classes we considered in the experiment to determine the effectiveness of outdoor mathematics activities. One class was assigned as the experimental group while the other as the conventional group. The experimental group engaged in outdoor mathematics activities utilizing appropriate detailed lesson plans. These included hands-on measurements using natural elements such as trees, rocks, and playground equipment to teach concepts of length, width, and height. In later activities, standard measuring tools were used, such as meter sticks, tape measure, and weighing scale. During the outdoor activities, the students engaged in real-life applications of geometry by exploring the shapes of objects in the outdoor environment and identifying geometric properties. On the other hand, the conventional group was exposed to the conventional classroom-based teaching approach using the lecture method. The pre-test and post-test were administered before and after the experiment, respectively.

2.2. Research respondents

The respondents of this study were 78 grade 7 students from a public high school in Bongao, Tawi-Tawi, Philippines who were officially enrolled during the school-year 2023-2024. The choice of the

school was purposive for two reasons. First, the school is classified as medium-sized relative to other high schools within the province. Second, the sections are organized as heterogeneous and with comparable abilities which is important in this experimental study. Grade 7 students from two of the intact sections were selected as the research respondents. Each class was randomly assigned as either the experimental or the control group. One section with 33 students was exposed to outdoor mathematics approach, while the other section with 45 students was taught with the conventional mathematics teaching approach. Both class has more than the minimum number of participants for an experimental research per Cohen *et al.* [33] recommendation. This cooperating school is under the direct supervision of the Ministry of Basic, Higher, and Technical Education (MBHTE)-Tawi-Tawi Schools Division.

2.3. Research instruments

Two instruments were used in gathering appropriate data to answer the research questions. The first instrument was a researcher-made test. It is a multiple-choice type of test that is composed of pre-test and post-test of similar construction. The pre-test and the post-test were administered to determine the ability of grade 7 students on measurement involving basic concepts, as well as real-life application. These instruments were also used to determine if there was a significant difference in the learning gains of the two groups after the experiment. Before the final administration, the instruments underwent validation by the panel of expert and was pilot-tested in a different school. A Cronbach's alpha was run to determine the reliability coefficient of the test and its two subtests. This 40-item researcher-made test was found to have a reliability coefficient of 0.82 indicating its highly acceptable reliability.

Another instrument used was a perception checklist. It was used to determine the grade 7 students' perception on outdoor mathematics activities in the experimental group. The checklist included aspects of the outdoor mathematics activities such as usefulness, motivation, performance, and assessment.

2.4. Data gathering procedure

The data collection began with the researchers requesting a letter of permission from the dean of the college of education of the university where the researchers are connected. Following this, permission was sought from the school's principal to conduct the study. Upon obtaining permission, the researchers made arrangement with the respective math teachers of the two grade 7 classes. Permission from the parents or guardians of the students was also sought as part of the ethical consideration. Upon approval, the researchers personally administered the pre-test to the respondents before implementing the lessons. The researchers then conducted the actual implementation of the lessons with the respondents for five whole weeks. There were 33 students exposed to the experimental approach, while 45 students were taught using the conventional approach. After the period of lesson implementation, the researchers administered the post-test. Perception checklists were also administered to the students from the experimental group the next day. Subsequently, the researchers collected the questionnaires, checked, tallied, tabulated, scored, analyzed, and interpreted the data.

2.5. Data analysis procedure

Descriptive statistics such as mean and standard deviation were used to treat the data collected from the pre-test, post-test, and students' perception checklist. A *t*-test for independent samples was utilized to determine whether the grade 7 students exposed to outdoor mathematics activities have significantly higher learning gains on measurement in terms of basic concepts and real-life application than those with the conventional group.

3. RESULTS AND DISCUSSION

3.1. Students' performance on measurement

Before the intervention, the mathematical ability of the grade 7 students from both experimental and conventional groups in terms of basic concepts and real-life applications was computed. This was done by analyzing the students' pre-test scores using mean and standard deviation. Results are found in Table 1.

As seen in Table 1, both the conventional and the experimental classes performed on the same level of below satisfactory on measurement before the intervention. The pre-test scores of the conventional ($M=4.27$, $SD=1.86$) and experimental groups ($M=6.18$, $SD=1.74$) in terms of the basic concept of measurement were both interpreted as below satisfactory. The same level of below-satisfactory performance can also be seen in the experimental ($M=4.94$, $SD=2.87$) and the conventional classes ($M=5.93$, $SD=2.49$) along real-life application of measurement concepts. Overall, the students from the experimental class had a similar level of performance in measurement concepts to those from the conventional class. This indicates that the two groups of students under study are of comparable abilities in measurement. After the experiment, the mathematical performance of the grade 7 students from the experimental and the conventional groups was determined. This was done by describing the post-test scores using mean and standard deviation. Results are found in Table 2.

Table 1. Performance of the grade 7 students in the pre-test on measurement concepts

No.	Concept	M	Conventional group		M	Experimental group	
			SD	Interpretation		SD	Interpretation
1	Basic concept	4.27	1.86	Below satisfactory	6.18	1.74	Below satisfactory
2	Real-life application	5.93	2.49	Below satisfactory	4.94	2.87	Below satisfactory
	Overall	5.1	2.18	Below satisfactory	5.86	2.31	Below satisfactory

Note: excellent (12.51-15.00), very satisfactory (10.01-12.50), satisfactory (7.51-10.00), below satisfactory (3.76-7.50), and poor (0.00-3.75).

Table 2. Level of performance of the grade 7 students in the post-test on measurement concepts

No.	Concept	M	Conventional group		M	Experimental group	
			SD	Interpretation		SD	Interpretation
1	Basic concept	5.91	2.89	Below satisfactory	12.45	2.62	Very satisfactory
2	Real-life application	7.16	2.84	Below satisfactory	10.03	1.76	Very satisfactory
	Overall	6.54	2.87	Below satisfactory	11.24	2.19	Very satisfactory

Note: excellent (12.51-15.00), very satisfactory (10.01-12.50), satisfactory (7.51-10.00), below satisfactory (3.76-7.50), and poor (0.00-3.75).

As illustrated in Table 2, the result demonstrates a notable difference in the grade 7 students' performance in both fundamental concepts and real-life application of measurement. Post-test scores of students from the conventional group were still below satisfactory ($M=6.54$, $SD=2.87$). However, the post-test scores of the experimental group significantly increased to a level deemed as very satisfactory ($M=11.24$, and $SD=2.19$). The data from the post-test revealed that in terms of understanding the basic concepts, the conventional group was below satisfactory ($M=5.91$, $SD=2.89$) in contrast to the students in the experimental group who obtained a very satisfactory score ($M=12.45$, $SD=2.62$). Similarly, the post-test score of students in terms of real-life application of the conventional group was below satisfactory ($M=7.16$, $SD=2.84$), while the experimental group performed at a very satisfactory level ($M=10.03$, $SD=1.76$). The finding suggests that incorporating outdoor activities significantly improves the performance of grade 7 students in mathematics, both in understanding basic concepts and applying these concepts to real-life situations. Not surprisingly, similar result was obtained in the study of Widada *et al.* [34] on the use of outdoor activities and its effect on students' problem solving ability.

3.2. Effects of outdoor mathematics activity (OMA) on students' ability

The learning gains of the grade 7 students from both the experimental and the conventional groups were statistically compared. This was done by obtaining the mean difference of the individual students' scores in pre-test and post-test and computing a *t*-test for the independent samples. The results are shown in Table 3.

As presented in Table 3, the result revealed that grade 7 students taught mathematics using outdoor activities had significantly higher learning gains compared to those taught in the conventional approach both in terms of basic concept of measurement ($t(75)=8.40$, $p=0.00$) and its real-life application ($t(75)=7.36$, $p=0.00$). Overall, students in the experimental group obtained significantly higher learning gains compared to the conventional group ($t(75)=7.88$, $p=0.00$). The findings strongly suggest that using outdoor activities to teach mathematics significantly improves the performance of grade 7 students in measurement. This support one of the authors' contentions that outdoor activities and measurement are naturally connected. The use of real-life objects during the outdoor activities makes students remember and understand math better by fostering connections among math concepts with issues in their environment [35].

Table 3. Learning gains of the experimental and conventional group

Concept	Conventional M-dif.	Experimental M-dif.	<i>t</i>	<i>p</i> -value (1-tailed)	Interpretation
Basic concepts	1.63	6.27	8.40	0.00	Significant
Real-life applications	1.22	5.09	7.36	0.00	Significant
Overall	1.42	5.68	7.88	0.00	Significant

Note: significant at $\alpha \leq 0.05$

The outcomes of this study align with previous researches corroborating the positive influence of outdoor learning approaches on students' academic achievement. Khan *et al.* [36] have illustrated that implementing outdoor lessons within a redesigned school environment led to improved academic performance, fostered collaboration and encourage exploration. Similarly, Priyadi and Yumiati [37] and Pearce [38] have found that outdoor activities better improves students' achievement in mathematics

compared to conventional learning approach. These findings suggest that teachers should plan and use outdoor activities to improving their students' math achievement particularly on measurement concepts.

3.3. Students' perception of OMA

The researchers also determined the perception of grade 7 students on the use of outdoor math activities from the experimental groups in terms of its usefulness, motivation, performance, and assessment. The summary results of the perception checklist are shown in Table 4. As shown in Table 4, it is revealed that the student's perception on the use of outdoor activities in mathematics was generally positive. The lessons with outdoor mathematics were rated excellent in three categories such as usefulness ($M=4.61$, $SD=0.42$), motivation ($M=4.56$, $SD=0.47$), and assessment ($M=4.51$, $SD=0.51$). Meanwhile, it was rated very satisfactory in terms of performance ($M=4.39$, $SD=0.51$). The findings showed that after being exposed to outdoor activities, students developed positive perception on using outdoor activities across these various dimensions. These findings further suggest that students found outdoor activities highly engaging and beneficial in the learning of measurement concepts. These align with the previous findings of Marpa and Tolentino [39] who found that high school students' exposure to outdoor mathematics influenced their perception of the subject positively as students gained appreciation of the diverse applications of mathematics in real-life contexts.

Excellent ratings given by students on motivation indicates that the respondents found the outdoor activities fun and engaging. This finding underscores the importance of integrating outdoor activities because mathematics is considered as the most difficult subject by most students. This finding is further supported by Marpa and Tolentino [40] and Fernandes and Vale [41] who concluded that bringing mathematics outside of the classroom can have a positive impact on students' motivation and interest.

Table 4. Students' perception on the use of outdoor activities in mathematics

No.	Outdoor math activities	<i>M</i>	<i>SD</i>	Interpretation
1	Usefulness	4.61	0.42	Excellent
2	Motivation	4.56	0.47	Excellent
3	Performance	4.39	0.51	Very satisfactory
4	Assessment	4.51	0.51	Excellent
	Overall	4.52	0.48	Excellent

Note: excellent (4.51-5.00), very satisfactory (3.51-4.50), satisfactory (2.51-3.50), fair (1.51-2.50), and poor (1.00-1.50).

4. CONCLUSION

Based on the findings of the study, it is concluded that using outdoor activities is effective in enhancing students' performance in mathematics particularly on basic concepts and real-life applications of measurement. Students retain the math concepts better because it uses real-world and authentic applications of measurement concepts. Beyond the academics, the study concludes that the use of outdoor activities is highly beneficial in improving students' engagement and motivation in learning mathematics. This innovative approach is helpful to students who perceive mathematics as disengaging and challenging; hence, this study offers pedagogical implications to mathematics teaching. Finally, the use of outdoor activities in mathematics class is highly recommended to teachers. Future studies may explore the used of outdoor math activities in teaching other math topics and in different grade levels.

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AUTHOR CONTRIBUTIONS STATEMENT

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Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Amit T. Tanaji	✓	✓			✓	✓	✓	✓	✓		✓			
Alnajir H. Usman	✓	✓			✓	✓	✓	✓	✓		✓			
Potchong M. Jackaria	✓	✓	✓	✓	✓		✓			✓	✓	✓	✓	
Aljemedin S. Jaudinez	✓			✓						✓		✓	✓	
Al-Jayson U. Abubakar	✓			✓						✓		✓		

C : Conceptualization

M : Methodology

So : Software

Va : Validation

Fo : Formal analysis

I : Investigation

R : Resources

D : Data Curation

O : Writing - Original Draft

E : Writing - Review & Editing

Vi : Visualization

Su : Supervision

P : Project administration

Fu : Funding acquisition

CONFLICT OF INTEREST STATEMENT

The authors confirm that there are no conflicts of interest related to financial matters or personal connections that might have influenced the research findings presented in this paper.

INFORMED CONSENT

Prior to the administration of the study, the informed consent from all the participants and their parents were sought. Provided informed consent. The respondents were informed of the study objectives and of their right to discontinue participation at any time.

ETHICAL APPROVAL

The research has complied with all the relevant national regulations and institutional policies in accordance with the tenets of the Helsinki Declaration and has been approved by the authors' institutional duly constituted review panel.

DATA AVAILABILITY

The research data obtained from this study and subsequently used in the analysis can be obtained from the corresponding author through reasonable request. The dataset is not publicly accessible due to privacy and ethical considerations.

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BIOGRAPHIES OF AUTHORS



Amit T. Tanaji    obtained his bachelor of secondary education degree major in mathematics from the Mindanao State University-Tawi-Tawi College of Technology and Oceanography, Tawi-Tawi, Philippines. Aside from the academics, he is an active student leader. He can be contacted at email: tanajiamit08@gmail.com.



Alnajir H. Usman    finished his bachelor of secondary education degree major in mathematics from the Mindanao State University-Tawi-Tawi College of Technology and Oceanography, Tawi-Tawi, Philippines. His interest in outdoor mathematics stems from his experience while in high school. He can be contacted at email: usmanalnajir@gmail.com.



Potchong M. Jackaria    is an associate professor at the Department of Science and Mathematics Education, College of Education, Mindanao State University-Tawi-Tawi College of Technology and Oceanography in Tawi-Tawi, Philippines. He had extensive experience teaching in different public schools handling elementary-level mathematics. He obtained his master's degree in education in administration and supervision from Mindanao State University-Tawi-Tawi College of Technology and Oceanography and a master of science education major in mathematics from Mindanao State University-Iligan Institute of Technology. He was is interested in research areas including mathematics teaching, education technology, professional development, and education policy. He can be contacted at email: potchongjackaria@msutawi-tawi.edu.ph.



Aljemedin S. Jaudinez    is an assistant professor at the Mindanao State University-Tawi-Tawi, Philippines. He obtained his master's degree in mathematics education from the University of the Philippines Diliman as an Academic Excellence and Best Thesis Awardee, where he served as a test item writer in a National Basic Education Exit Assessment. He had educational training abroad such as the Hiroshima Essential Training in Japan (2017) and the Science, Technology, Engineering, and Mathematics (STEM) Education Workshop in Cambodia (2018). He is an organizer, facilitator, and resource speaker in local and national teacher training on STEM education. He can be contacted at email: aljemedinjaudinez@msutawi-tawi.edu.ph.



Al-Jayson U. Abubakar    is a mathematics teacher at Mindanao State University-Tawi-Tawi Integrated Laboratory School. He finished both his bachelor's in secondary education major in mathematics and master of science in teaching (MST) mathematics from the same university. He has attended further trainings at National University of Singapore and Northern Illinois University, USA. His research interests include mathematics teaching, feedbacking, and graph theory. He can be contacted at email: al-jaysonabubakar@msutawi-tawi.edu.ph.